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The Accessibility Quotient: A New Measure of Open Access

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Abstract

INTRODUCTION The Accessibility Quotient (AQ), a new measure for assisting authors and librarians in assessing and characterizing the degree of accessibility for a group of papers, is proposed and described. The AQ offers a concise measure that assesses the accessibility of peer-reviewed research produced by an individual or group, by incorporating data on open availability to readers worldwide, the degree of financial barrier to access, and journal quality. The paper reports on the context for developing this measure, how the AQ is calculated, how it can be used in faculty outreach, and why it is a useful lens to use in assessing progress towards more open access to research. **METHODS** Journal articles published in 2009 and 2010 by faculty members from one department in each of MIT's five schools were examined. The AQ was calculated using economist Ted Bergstrom's Relative Price Index to assess affordability and quality, and data from SHERPA/RoMEO to assess the right to share the peer-reviewed version of an article. **RESULTS** The results show that 2009 and 2010 publications by the Media Lab and Physics have the potential to be more open than those of Sloan (Management), Mechanical Engineering, and Linguistics & Philosophy. **DISCUSSION** Appropriate interpretation and applications of the AQ are discussed and some limitations of the measure are examined, with suggestions for future studies which may improve the accuracy and relevance of the AQ. **CONCLUSION** The AQ offers a concise assessment of accessibility for authors, departments, disciplines, or universities who wish to characterize or understand the degree of access to their research output, capturing additional dimensions of accessibility that matter to faculty.

Implications for Practice:

- This study offers a new measure, the Accessibility Quotient or AQ, which takes an assessment of potential openness based on publisher policies for sharing peer-reviewed research, and adds information about journal quality and price.
- The AQ can be used as a concise way to represent several variables of accessibility along a single continuum, providing librarians with an additional tool for outreach to authors and administrators.
- In combining three measures of interest to authors – price, quality, and shareability – the AQ is a means of reaching authors quickly with a summary of information that matters to them about their publishing environment.
- The AQ can be assessed for an author, a group of authors, or an entire university, providing a means of describing the barriers to access for any group of articles.

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INTRODUCTION

Many academic libraries have begun actively recruiting faculty papers for institutional repositories, motivated by a belief that one of the key roles libraries can play in the 21st century is to collect and curate locally-created content and thus make it more accessible to the world, place it in an institutional context, and increase its impact. These efforts are often further motivated by a campus open access policy or statement of open access principles.¹ As an integral and essential part of these recruitment efforts, libraries are taking up the role of educating authors about their rights to share their work.

This kind of outreach has taken center stage at the MIT Libraries in the wake of the faculty's passage of a university-wide open access policy in March 2009. The policy gives MIT a license to make faculty work available through MIT's repository, allowing the faculty's peer-reviewed research to be shared as broadly and cheaply as the World Wide Web makes possible, without the limitations of standard publisher policies ("MIT Faculty," 2009). Sharing with faculty the story of the reasons for the policy—including raising awareness about the restrictions of publisher policies and the barriers to access that exist with standard publishing channels—has become a critical foundation for the Libraries' outreach under the policy.

In thinking about how to tell that story, we have made an effort to identify data of interest to our authors. We know from previous conversations with authors that they are interested in how friendly their specific publishers are to open posting of peer-reviewed articles on the web. So we realized that our outreach should be grounded in a full understanding of publisher policies on posting the authors' peer-reviewed versions, and that we would need ways to concisely convey this information in a data-driven and visual form to busy faculty.

¹ Since Harvard's Faculty of Arts & Sciences established the first permission-based, faculty-driven open access policy in the United States in 2008, MIT and 14 other U.S. universities, colleges, or schools have followed this model. These U.S. universities with "permission-based" policies are just a small subset of the total of 170 universities and other institutions who have established statements of principles or support for open access, as reported by the Registry of Open Access Repositories Mandatory Archiving Policies (ROARMAP, at <http://roarmap.eprints.org/>). At the time of this writing, faculty at Princeton University and Bucknell University had just passed open access policies, and the University of Pennsylvania had just announced open access principles.

As a first step towards this goal, we sought ways to characterize the level of sharing, or openness, possible under standard publisher agreements. Openness has typically been defined in terms of whether rights holders allow access with no charge to scholarly work on the web (Suber, 2004), and the first part of our study looks at this factor in the context of several MIT departments.

We also knew from conversations with faculty leading up to their vote on the Open Access Policy (where discussions often emphasized the barrier of journal price) that they were interested in the cost of subscription journals, which is viewed as a major barrier to access, particularly in underdeveloped parts of the world. We therefore wanted a measure that would incorporate not only legal barriers, in the form of publisher policies on sharing, but also financial barriers, in the form of relative price. This approach was supported in part by one aspect of the original definition of open access from the Budapest Open Access Initiative (2002), which emphasizes not only "free availability on the public internet," but also access to articles "without financial...barriers".² Finally, we wanted to reflect journal quality in the analysis, if possible, since faculty are drawn to openness but typically only if journal quality is high (Austin, 2008, pp. 25-27).

With these goals for a new, multifaceted measure in mind, we developed the "Accessibility Quotient," or AQ, a concise measure that assesses three key factors affecting access: openness to readers worldwide, financial barriers to access, and journal quality. We built the AQ using measures of publisher policies on open sharing of peer-reviewed papers, journal prices, and citation rates. By incorporating these variables into a single metric, we have created a measure that can assess the accessibility of peer-reviewed research produced by an individual or group. Here, we describe how this measure is calculated, how it can be used in faculty outreach, and why it is a useful lens to use in assessing progress towards more open access to research.

LITERATURE REVIEW

The overarching question in our work was how open

² The Budapest Open Archives Initiative focuses on full open access rather than lower cost journals, but the concept of lowering financial barriers is incorporated in their statement about open access, e.g. in calling for "all interested institutions and individuals to help open up access to the rest of this literature and remove the barriers, especially the price barriers, that stand in the way."

publishers are with respect to the peer-reviewed version of articles in different disciplines. Quite a few studies look at self-archiving in different fields (e.g., Antelman, 2006; Bjork et al., 2010), but they generally do so from the perspective of author practice and preference, not publisher policies or cost and quality of journals. Since our goal was to have a motivating story to tell faculty, we were first interested in looking at what authors *can* do rather than what they *actually* do. Several studies address this.

Morris (2009) reported on a 2008 survey which included more than 200 publishers whose journals represented nearly 75 percent of articles in ISI for 2007, as well as a subset of authors of papers from these journals. The study found that more than 80 percent of the journals permitted authors to self-archive the peer-reviewed version on their personal or departmental website; more than 70 percent permitted self-archiving to an institutional repository; and about 50 percent permitted self-archiving to a subject repository. The survey also found that 50 percent of authors believed it was “very important” or “extremely important” to be able to post their papers to a personal or departmental website, with similar responses for subject repositories and institutional repositories. Stated broadly as the desire to “provide copies to others outside your institution,” more than 70 percent reported this was extremely or very important.

Coleman (2007) looked at copyright agreements for 52 library and information science journals and found that 90 percent permit self-archiving in some form. That number is skewed, however, because there were no copyright agreements found for 62 percent of the journals, and for these Coleman assumed authors could archive post-print. This is a generous assumption that is likely to have overstated the archiving rights.

While these two studies are more than a few years old, data from the University of Nottingham’s open access SHERPA/RoMEO database summarizing publisher policies on self-archiving (University of Nottingham, n.d.), provides updated figures that are not at odds with the prior studies. SHERPA/RoMEO data indicates that as of January 2012, 57 percent of publishers worldwide support self-archiving of a peer-reviewed version in some manner.

Other studies address authors’ understanding of what

they can do with their papers, which is important when conducting outreach activities. Swan and Brown (2005) write that authors are not well informed about their rights. In an international survey of nearly 1,300 authors, they found that only 10 percent knew of the SHERPA/RoMEO database summarizing publisher policies on self-archiving, and nearly a quarter did not know who owned the copyright to their articles. Copyright, Swan and Brown write, “remains one of the reasons authors offer as a deterrent to self-archiving” (2005, p. 56).

Antelman (2006, p. 87) also found a “lack of awareness” on the part of authors in terms of signed author agreements and what their rights are in her survey of self-archiving across six social science disciplines. Covey (2006), whose study surveyed scholarly publishing practices at Carnegie Mellon, found that 56 percent of faculty did not understand their rights or were unsure of their rights. The University of California’s widely-read study “Assessing the Future Landscape of Scholarly Communication” (Harley et al 2010) reports on article sharing practices in seven disciplines, finding a wide range of practices including, for example, a culture of consistent sharing in economics, and more limited sharing outside formal publication channels in biology.

The studies addressing author rights awareness paint a clear picture of authors who want to share their peer-reviewed research but do not know whether their publishers actually allow them to do so. Our study addresses the need implied by these studies to find ways to educate authors about what publishers permit.

METHODS

We devised a study that would give us specific information for our authors about how openly available they could make their own work as a way to help them better understand how their publishers support the faculty goal of sharing their work openly on the web.

For this study, we examined journal articles published in 2009 and 2010 by faculty members from one department in each of MIT’s five schools. The departments selected were Linguistics & Philosophy, Mechanical Engineering, the Media Lab, Physics, and the Sloan School of Management. We chose these departments because they are representative of both the scholarly work being done at MIT and of a wide range of disciplines, including

humanities, social science, science, and engineering. Publication lists for these faculty members were collected using free and licensed databases; this set of databases was chosen by MIT subject librarians because, taken together, they offer almost complete coverage of MIT's research fields. In total, faculty from these departments published 1,430 journal articles during the years covered by the study. In our study, we focused on the peer-reviewed versions of these articles, whether the author's final manuscript or the final published article. We did so because of the importance of peer review as a filtering mechanism for authors and readers, and because MIT faculty focus specifically on the peer-reviewed version in their open access policy ("MIT Faculty," 2009). Though Harnad et al. (2004) and others have included pre-prints (the version of the article authors first submit to journals) in accounts of publisher policies allowing posting on the web, according to Suber (2010), "all the major OA initiatives for scientific and scholarly literature insist on [the] importance" of peer review.

Phase I: Publisher policies on open sharing of peer-reviewed version

We used SHERPA/RoMEO (University of Nottingham, n.d.) to determine which of the papers in these lists were permitted by publishers to be shared in their peer-reviewed version. The database uses language in author copyright agreements and policy statements to determine publishers' self-archiving policies, and assigns publishers a color based on how much self-archiving they allow and for which article version (Jenkins, Proberts, Oppenheim, & Hubbard, 2007). Using the SHERPA/RoMEO data, we calculated the percentage of faculty articles in a given department that can be shared openly in a peer-reviewed version according to publisher policy.

Phase II: Accessibility Quotient

The second phase of the study was to devise a measure that would combine the assessments from Phase I of the openness granted by publisher policies and author agreements, with measures of affordability and quality of journals. This measure, which we call the Accessibility Quotient (AQ), incorporates these variables into a single metric, allowing us to quantify the accessibility of peer-reviewed research produced by an individual or group. The AQ is a scale that ranges from 0 (least accessible) to 1 (most accessible). We calculated the AQ using UC Santa

Barbara economist Ted Bergstrom's Relative Price Index³ (Bergstrom & McAfee, 2010) and data from SHERPA/RoMEO.

To calculate the AQ for the group of publications in each department, we needed to collect three pieces of data on each journal represented in the publication lists:

- The number of papers in the list that appear in the journal.
- The Relative Price Index (RPI) for the journal. The RPI takes the average of the cost per article and cost per citation for a particular journal (this is known as the Composite Price Index or CPI) and normalizes it based on the CPI for other journals in that field.
- A value of 0 or 1, representing whether the publisher allows sharing of the peer-reviewed version of articles published in the journal (0) or not (1). We obtained this value from SHERPA/RoMEO. A value of 0 corresponds to a SHERPA/RoMEO color of green or blue (can share peer-reviewed), and a value of 1 corresponds to a SHERPA/RoMEO color of yellow or white (can't share peer-reviewed).⁴

³ Bergstrom's research into journal prices is long-standing, well known, and openly available. He defines his "CPI" and "RPI" measures this way: "Composite Price Index: The Composite Price Index (CPI) is the geometric mean of the Price Per Article and the Price Per Citation." "Relative Price Index: The relative price index (RPI) for a journal is its CPI divided by the average CPI of non-profit journals in its subject category. Journals that have multiple subject listings are factored into the average CPI for each field that they belong to. The RPI of such a journal is its CPI divided by the average of the average of CPIs for the subjects listed for it." See: <http://www.journalprices.com/> for an overview of Bergstrom's journal pricing data and <http://www.mcafee.cc/Journal/explanation2010.html> for definitions of the CPI and RPI.

⁴ For Elsevier articles, we altered the SHERPA/RoMEO color from Green (can share) to Yellow (cannot share), because, as SHERPA indicates, while Elsevier normally allows "voluntary deposit by author of author's post-print...on institution's open scholarly website including [an] Institutional Repository," there is a different policy for authors on campuses where there is an open access policy: "Deposit due to Funding Body, Institutional and Governmental mandate [is] only allowed where [a] separate [sic] agreement between repository and publisher exists." In other words, authors on campuses that have open access policies are prohibited from the kind of manuscript sharing other authors are allowed, unless the campus has negotiated a special agreement. Since MIT faculty authors have an open access policy, SHERPA's Yellow is a more accurate representa-

As we have mentioned, our goal was to devise a metric which incorporated measures of openness, journal price (or affordability), and journal quality; the three pieces of data described above give us all of these measures. The measure of openness comes from the SHERPA/RoMEO classifications: a 0 means open, a 1 means not open. The measures of journal price and journal quality are incorporated together into the RPI. In Bergstrom's calculation of the RPI, a higher price results in a higher RPI. Bergstrom also includes quality in the RPI in the form of citations to the journal: the more citations a journal receives, the lower the journal's RPI.

Bergstrom uses the term "value" to describe the cost and quality information that the RPI conveys; we will continue the use of this term in our paper. Journals with a high RPI (over 2.0) have a lower value, and journals with a low RPI (under 1.25) have a higher value. If we think of publications in lower value journals—that is, journals that cost more per citation and per article—as offering high barriers to access, then we can interpret the RPI as a measure of barriers to access.

Therefore, we used the RPI to calculate the raw maximum "access barrier value" that a particular publication list offers, not taking into account any open sharing. We calculated the access barrier value by multiplying the number of papers and the RPI for each journal, and then adding the results together. A higher RPI for a particular journal would mean lower value, thus a higher barrier to access, and therefore a higher access barrier value.

However, openly shared, peer-reviewed papers have no cost to the reader and therefore offer no barriers to access. And so we also calculated the theoretical minimum access barrier value for a particular publication list; it is the raw value of the barriers to access if all of the papers which are permitted to be shared openly are actually shared openly. We found this value by multiplying the number of papers, the RPI, and the 0 or 1 value for shareability together for each journal, and then adding the results together.

Using these two access barrier values, we calculated the percentage of barriers that would still exist if all papers for which the publisher allows open sharing are openly shared. That percentage is the theoretical minimum access

tion of the amount of sharing allowed on papers in our data set than is the default color of Green. See: <http://www.sherpa.ac.uk/romeo/search.php?id=30&format=full>

barrier divided by the maximum access barrier value. The result represents the percentage of access barrier value that would still exist given the authors sharing as much as their publishers allow. However, our goal in measuring accessibility was to measure the opposite: the percentage of access barrier value that is removed as a result of the rights afforded by publishers. And so we define the Accessibility Quotient as this result subtracted from 1.

In mathematical terms, the AQ can be calculated from the following equation:

$$AQ = 1 - \frac{\sum_i c_i R_i S_i}{\sum_i c_i R_i}$$

Where:

- c_i is the count of articles in the publication set which appear in journal i .
- R_i is the RPI of journal i .
- S_i is the value (0 or 1) assigned to journal i based on the publishing policy as denoted on SHERPA/RoMEO.

Since S_i is either 0 or 1, the entire equation is between 0 and 1, where an AQ of 0 means that none of the articles in this publication set are allowed to be openly shared in their peer-reviewed version and an AQ of 1 means that all articles in this set may be openly shared in their peer-reviewed version.

In practice, some of the journals which faculty from these five departments published in were either not covered by SHERPA/RoMEO or not assigned a Relative Price Index in Bergstrom's system. We disregarded these papers in our calculation of the AQ. For example, we excluded 90 papers from the study because they were not in journals covered by SHERPA/RoMEO.

The calculation of the AQ for MIT's Media Lab is displayed in Table 1 (following page). The Articles and RPI columns are multiplied together to obtain the Maximum ABV (access barrier value), and the Articles, RPI, and Sherpa value columns are multiplied together to obtain the Minimum ABV. The Maximum ABV and Minimum ABV columns are then summed, and the AQ is calculated as the Minimum ABV divided by the Maximum ABV, subtracted from 1.

Table 1. Calculation of the AQ for MIT's Media Lab

Journal Title	Articles	RPI	Sherpa Value	Maximum ABV	Minimum ABV
ACM Transactions on Graphics	5	0.09	0	0.45	0
AI EDAM	1	5.86	0	5.86	0
Ai Magazine	1	1.25	0	1.25	0
Autonomous Robots	1	3.17	0	3.17	0
Behavioral Ecology and Sociobiology	2	3.55	0	7.1	0
Communications- ACM	1	0.11	0	0.11	0
Computer Graphics Forum	2	1.5	1	3	3
Computers and Graphics	1	4.29	1	4.29	4.29
Epilepsia	1	0.81	1	0.81	0.81
Human Factors	1	1.21	1	1.21	1.21
IEEE Journal on Selected Areas in...	1	0.57	0	0.57	0
IEEE Pervasive Computing	3	1.48	0	4.44	0
IEEE Transactions on Biomedical Engineering	1	0.49	0	0.49	0
IEEE Transactions on Information Technology...	4	1.18	0	4.72	0
IEEE Transactions on Neural Systems and...	1	0.93	0	0.93	0
IEEE Transactions on Pattern Analysis and...	1	0.74	0	0.74	0
IEEE Transactions on Robotics	1	0.64	0	0.64	0
IEEE Transactions on Systems, Man, and...	2	0.28	0	0.56	0
IEICE Transactions on Information and Systems	1	0.29	0	0.29	0
International Journal of Robotics Research	2	2.19	1	4.38	4.38
Journal of the Optical Society of America A	1	0.98	0	0.98	0
Nano Letters	1	0.15	1	0.15	0.15
Nature	3	0.66	1	1.98	1.98
Neuron	1	0.44	1	0.44	0.44
Optics Express	3	0	0	0	0
Personal and Ubiquitous Computing	1	2.82	0	2.82	0
Philosophical Transactions B: Biological Sciences	1	2.16	0	2.16	0
PLoS Computational Biology	2	0	0	0	0
Psychophysiology	2	0.69	1	1.38	1.38
Science	1	0.74	0	0.74	0
				55.66	17.64
				AQ: 0.683	

RESULTS

Phase I: Publisher policies on open sharing of peer-reviewed version

Overall, 64 percent of the publications examined in the study permitted a peer reviewed version to be shared. A summary of findings, divided into departments, can be seen in Table 2 (following page).

When communicating with faculty, we represent this data in pie charts (see Figure 1, following page).

Phase II: Accessibility Quotient

As described in more detail in the Methods section, we calculated the AQ using Bergstrom’s Relative Price Index and SHERPA/RoMEO’s database of publisher policies on open sharing. The result is a scale of accessibility that ranges from 0 (least accessible) to 1 (most accessible).

Table 2. Overall Findings: Number and Percentage of Peer-Reviewed Articles that can be Shared

Department	Total articles in journals listed in SHERPA/RoMEO	Peer-reviewed articles that can be shared	Percentage of shareable articles
Linguistics & Philosophy	24	13	54%
Mechanical Engineering	499	272	55%
Media Lab	54	37	69%
Physics	457	385	84%
Sloan School	306	151	49%
Totals	1,340	858	64%

Our results for the departments assessed appear in Figure 2, below.

The results show that 2009 and 2010 publications by the Media Lab (AQ of 0.683) and Physics (AQ of 0.634) have the potential to be more open than those of Sloan (AQ of 0.417), Linguistics & Philosophy (AQ of 0.550), and Mechanical Engineering (AQ of 0.552). As described

above, papers were excluded from these calculations when an RPI value or SHERPA/RoMEO color was not available for the journal. This had a strong effect on Linguistics & Philosophy (only 25 percent of published journal articles were used), less of an effect on Sloan (84.2 percent used) and the Media Lab (89.8 percent used), and a very small effect on Mechanical Engineering (92.0 percent used) and Physics (93.8 percent used).

Figure 1. Publisher Policy on Open Sharing: All Departments in Study

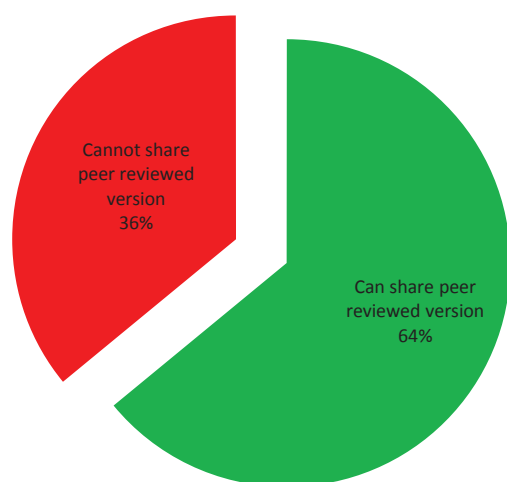
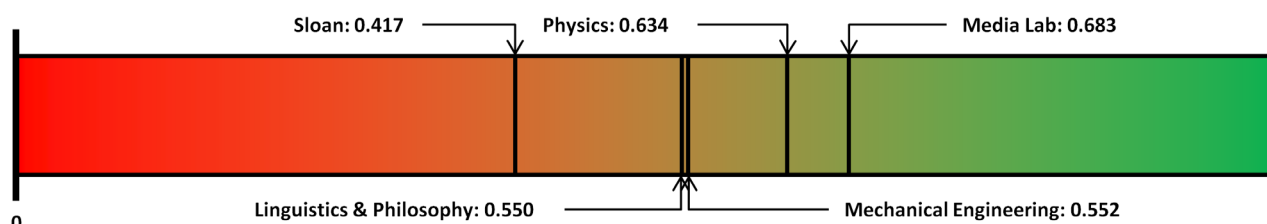


Figure 2. Accessibility Quotient for Five MIT Departments, 2009-10 Publications



DISCUSSION

This study generates several important questions that merit further discussion. Specifically, how can we interpret this data? What are the limitations of the study as it stands, and where could it be extended in the future to represent additional information? How can we apply the information that we have gained through this work?

Interpretation

In this study we demonstrated two different measures of the potential for open accessibility, both of which are useful in trying to understand the publishing environment for a selected group. Each measure has strengths which make it relevant when examining publishing habits and publisher policies for a particular author or group of authors.

The first phase of the study is a straightforward account of what publisher policies allow; the Mechanical Engineering faculty's percentage of 55 percent means that 55 percent of the papers published by faculty can be openly shared, in their post-peer-review version, through some means (author website, institutional repository, subject repository, etc.). The measure's strength is its clear description of an obvious characteristic of the data set. This data would be useful in outreach with authors, a way to help them quickly understand how friendly publishers in their discipline are to open posting, and what might be the benefit of an open access policy that increases the possibility for sharing regardless of the publisher policy.⁵

Sixty-four percent of the papers examined in the study can be openly shared, according to SHERPA/RoMEO. This is significantly higher than the overall 57 percent of publishers listed in SHERPA/RoMEO that allow sharing of the post-peer-review version (University of Nottingham, 2011). It is important to note that these percentages are not directly comparable, as every publisher publishes a different number of journals and papers. If the larger publishers are the 57 percent that allow sharing, then more than 57 percent of papers could be openly shared. However, SHERPA/RoMEO has not provided statistics at the journal level, and so the 57

percent is the best comparison point we can offer.

Because of this lack of directly comparable data, we cannot make definitive conclusions about the difference between the shareability in the MIT data set, 64 percent, and that of the SHERPA/RoMEO data set, 57 percent. It is possible that the difference is because publishers in the disciplines we studied are in general more permissive of sharing than publishers in other disciplines. Physics, for example, is known as a field where publishers often allow and sometimes even encourage sharing of published material through arXiv. Therefore, the percentage of papers that can be shared may be high as a result of our selection of departments in this study, rather than because those authors consciously chose to publish in journals that allow open sharing.

The second phase of the study provides a measure that modifies the percentages obtained in the first phase of the study by introducing Bergstrom's Relative Price Index. As described by Bergstrom and McAfee (2010), the RPI is essentially an inverse value measurement, where a journal with a high RPI (over 2.0) has a low value and a journal with a low RPI (under 1.25) has a high value. Therefore, a journal with a higher RPI that does not allow sharing of the post-peer-review version lowers the AQ, and a journal with a lower RPI that does not allow sharing of the post-peer-review version raises the AQ.

This distinction can be better illustrated by comparison to the first phase of the study: while the first phase of the study measures the percentage of papers that can be made open under publisher policies, the second phase essentially measures the percentage of "access barrier value" (described in the Methods section) that can be bypassed as a result of the open sharing allowed under publisher policies.

Put another way, looking at the two measures we included in our study, what the AQ offers beyond the basic summary of whether the peer-reviewed version can be shared is a quick grasp of how the shareability is modified by journal quality and journal price (as they are combined into the RPI). If the AQ for a set of articles is higher than the percentage of articles that are shareable according to SHERPA/RoMEO, the data set includes more titles that are a "high value" even if they cannot be shared—they are high quality and reasonably priced. If the AQ for a set of articles is lower than the percentage of articles that

⁵ Permission-based policies like MIT's, in which the faculty extend a license to MIT to exercise all rights under copyright, allow articles to be shared even if the publisher's standard policy prohibits such sharing, unless an author has opted out of the policy.

are shareable according to SHERPA/RoMEO, the data set includes titles that are a relatively “low value” and they cannot be shared—they are very expensive, even if high quality. For an author or administrator, this means that the AQ summarizes key dimensions that are of significant interest on campus, incorporating them along with openness, creating a measure that may have more meaning for authors than shareability alone.

A good example of how the two measures relate to each other is the case of the Physics faculty papers examined in this study. The first phase of the study showed that 84 percent of peer-reviewed papers published by Physics faculty could be shared. However, the AQ for this group of papers is 0.634; that is, 63.4 percent of the access barrier value can be bypassed by the open sharing allowed under publisher policies. Clearly, the AQ is quite a bit less than the percentage of papers that can be shared. This difference implies that the 16 percent of papers that cannot be shared are published in journals with a very low value. Indeed, a quick calculation shows that the physics papers which cannot be shared are in journals with an average RPI of 1.56, while the physics papers which can be shared are in journals with an average RPI of 0.50. While many papers can be shared openly, the few that cannot offer difficult barriers to access. As such, the AQ gives a less optimistic view of the potential accessibility of research in this field than the raw assessment of shareability as calculated in Phase I.

While an example in the other direction did not make itself apparent in this study, we could imagine a hypothetical example where 60 percent of a department’s faculty papers can be shared openly under publisher policies but where the AQ for this set of papers is 0.750. In this case, the 40 percent of papers that cannot be shared openly under publisher policies are published in journals with a very high value. In other words, while only a little more than half of the papers can have their peer-reviewed version shared, the papers which cannot be shared offer low barriers to access, because they are published in a journal which, for its field, is either low cost, high quality, or both. Therefore, the AQ would show a more optimistic view of the potential accessibility of research in this field.

The significant differences in percentages and in AQ values among departments can be interpreted as a good representation of the scholarly publishing atmosphere in those disciplines. Without generous publisher policies

and high value journals, faculty members in the Physics Department and the Media Lab would not be able to maintain such low barriers to their published research. As discussed above, faculty in the Physics Department in particular have a very open environment in which to publish their research. On the other hand, faculty in the other departments in the study (Mechanical Engineering, Linguistics & Philosophy, and Sloan School of Management) still face a publishing environment which creates significant barriers to access their published research; each of these departments has an AQ between 0.400 and 0.600, and faculty can only allow between 49 percent and 55 percent of their articles to be shared in accordance with publisher policies.

Limitations

While the data in the SHERPA/RoMEO database was incredibly valuable for our calculations, there are two aspects of the data that limited our study and should be taken into account.

SHERPA/RoMEO does not distinguish between rights afforded through publisher policies and rights afforded within the actual author copyright agreement, and so we do not make this distinction in our results. Nevertheless, the distinction has important implications for authors, and we suggest future studies to evaluate how sharing rights vary when relying on the author agreement only, since a publisher’s policy can shift at any time and does not provide the same assurance as the legally binding signed author agreement. A caveat here is that author agreements also change over time, and so information gathered from current author agreements may not be sufficient to examine a historical percentage of author agreements that allow sharing of the post-peer-review version.

In addition, when assigning a color ranking to a particular journal or publisher, SHERPA/RoMEO does not distinguish where the post-peer-review version may be shared. Different publisher policies and author agreements specify different rights for self-archiving, institutional repositories, and subject repositories, yet the database may assign these publishers the same ranking. Again, this distinction has important implications for authors, specifically with regard to their ability to contribute to various repositories in accordance with institute policies or regular discipline practice. A future study examining

how sharing rights vary based on location could give a more accurate concept of what publishers allow in certain disciplines. The SHERPA/RoMEO color rankings also do not capture other means of openness a publisher may engage in that could be meaningful for authors. For example, a publisher may be generally unfriendly to sharing of the peer-reviewed manuscript, but make the back runs of its journals openly available after a delay period.

Because our calculation of the AQ requires that we be able to obtain an RPI and a SHERPA/RoMEO color for each journal, we have dropped articles from our data when the journal is missing one of these data points. As described in the Methods section, for Linguistics & Philosophy, the lack of RPI values or SHERPA/RoMEO colors for journals has meant that we are building the AQ on only 25 percent of the journal articles in our sample. The AQ, therefore, may not be as accurate for fields that are not covered well by Bergstrom's RPI.

In our calculation of the AQ, we make the assumption that the count of citations to a particular journal is an accurate measure of journal quality. This assumption is certainly open to disagreement, as citation counts alone do not accurately represent the overall quality of a journal, and there are many other factors to be considered. A recent editorial in *Angewandte Chemie* by Jan Reedijk (2011) discusses some of the issues with using citation analysis as a representation of journal quality. As Reedijk notes, though, citation analysis (and in particular, the Impact Factor as published by the Institute of Scientific Information) is currently the most widely used metric for journal quality; as such, we decided to make this assumption in our calculations. Future modifications to the AQ could include the incorporation of other journal quality measures, perhaps which quantify other aspects of journal quality.

The strength of the AQ is that it combines measures of price, quality, and openness into a single concise measure. However, when we combine multiple factors into one number, we sacrifice specificity in favor of conciseness, and this weakness is worth noting. We consciously made this trade-off in order to describe accessibility with a single measure; we believe this is justified because such a scale will be compelling to our community and will offer a unique approach for fresh discussions about journals. But the loss of information that occurs when combining

measures should be acknowledged when discussing the AQ, and its use does not preclude having conversations about separate data on RPI or journal posting policies.

These limitations provide suggestions for future investigations to better understand those aspects of the scholarly publishing environment that our calculations do not represent.

Applications

The process described here can be applied to any group of publications to see the potential accessibility of that particular body of work. Groups of publications could be defined by a single author, a lab, a department, a university, or a group of authors working in a particular field across multiple institutions. These calculations can offer a picture of the publishing atmosphere in a particular field and an intuitive understanding of how author rights, journal cost, and journal quality affect barriers to research. In addition to giving a snapshot of the scholarly publishing environment, measures of potential accessibility can be used in planning outreach to faculty and senior administrative staff. These measures can help illustrate how much content can legally be made available, whether or not an institution has an open access policy in place. Early feedback from faculty suggests that while the figure alone is of interest, it raises many questions about how exactly it was calculated. Further work towards developing a concise explanation of the calculation of the AQ would help to make the measure more useful for faculty and staff. Measures of the potential for open accessibility can also be used to assess the potential for gathering papers for deposit into an institutional or subject repository. For both of these applications, the Phase I calculation would need to be revised to focus on publishers that allow posting in particular types of repositories (as discussed above, we did not make those distinctions here).

These measures could also help authors in certain disciplines to stay informed about scholarly publishing issues, making them aware of what they can do with their articles, or what their colleagues in their own or different disciplines are able to do with their publications. These tools help librarians answer the common questions authors ask: "Can't I just post anything anyway? And can't everyone get to whatever they need these days?" Both measures can be manifested in figures that quickly portray the restrictions that actually exist – on sharing, on

access, on openness.

Providing authors with these kinds of visualizations is expected to contribute toward raising author awareness about barriers to access, and could potentially encourage authors to make more informed choices when signing an author agreement. Awareness could also add support for a campus open access policy as a means of ‘overriding’ the restrictions depicted in these measures.

The AQ could be used as a baseline to assess progress in moving to more openness overall, and in certain fields. If used to assess a range of disciplines, as described here, it allows the disciplines to be placed along a continuum that suggests not only what the publishing environment is currently, but how, through access-friendly changes in publisher policy or pricing, openness could be increased.

CONCLUSION

Academic librarians need clear depictions of relevant data to support outreach related to author rights. Anecdotes about limits on access and conversations about rights retention are critical, but data clinches the point. Concise measures of issues that matter to our busy authors—can I post my paper? Can people around the world access my research?—offer an important way to raise awareness about their rights to their work, an essential step in assisting them and their institutions in meeting their goal of making their research as widely available as possible.

In this study, we have shown that SHERPA/RoMEO data can be used to assist librarians in depicting research shareability, and, importantly, that a new measure, the Accessibility Quotient, can capture additional dimensions of accessibility that matter to faculty. The AQ offers a concise assessment of accessibility for authors, departments, disciplines, or universities who wish to characterize or understand the degree of access to their research output. In combining three measures of interest to authors – price, quality, and shareability – the AQ offers librarians a means of summarizing information about a given publishing environment in a way that is relevant to our authors and campus leaders.

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